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(54) **ELECTRICAL COUPLING AND SWITCHING DEVICE WITH FLEXIBLE MICROSTRIP**

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(52) **U.S. Cl.** **439/188**; 439/944
(58) **Field of Search** 439/188, 944

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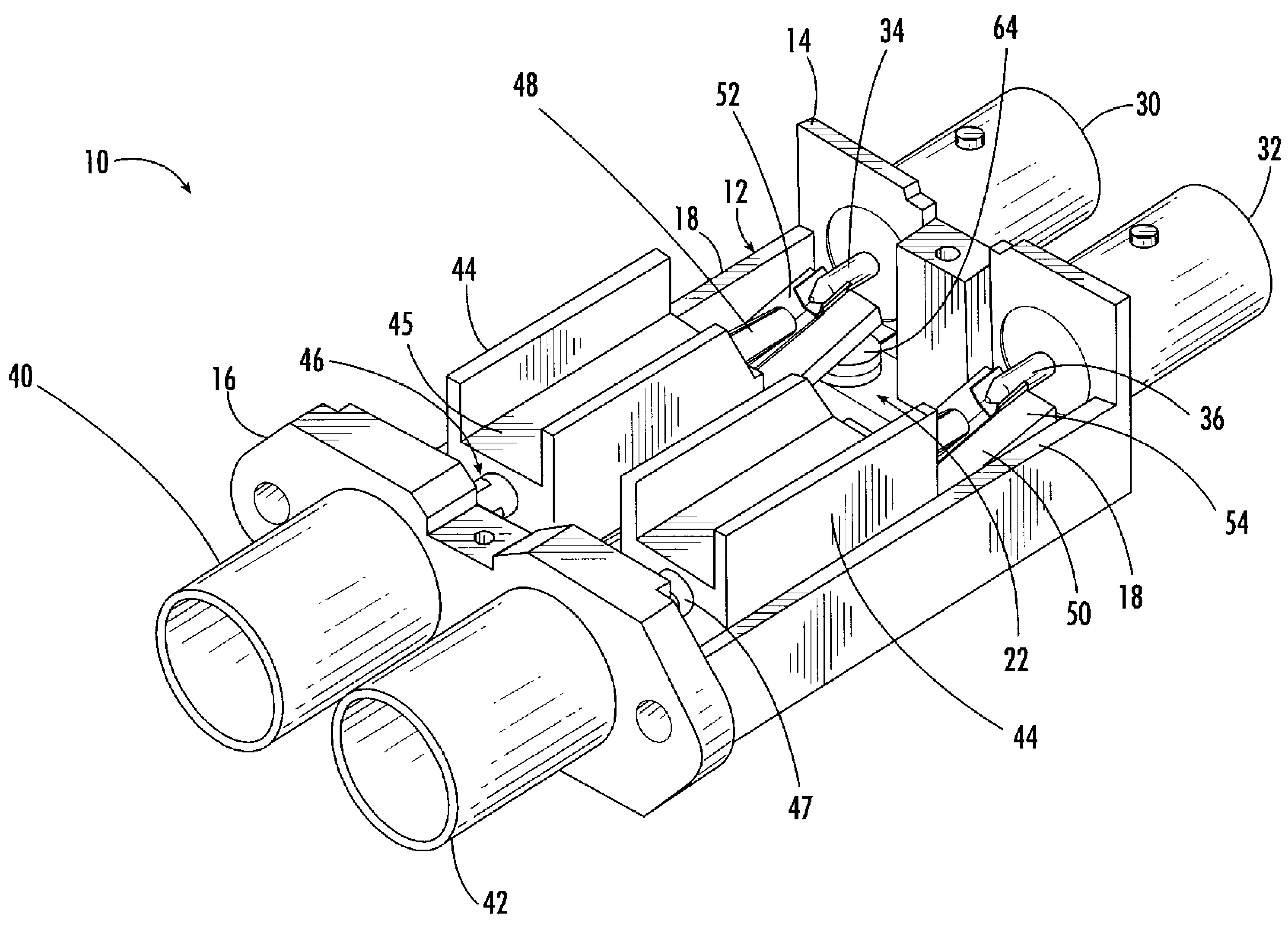
(57) **ABSTRACT**

An electrical coupling and switching device and associated method advantageous for use with signal bandwidths of 1.5 GHz or more is provided having a housing defining first and second equipment ports for use with coaxial plugs. The housing also defines first and second patch ports for receiving patch plugs, such as video-style plugs. A pair of actuators are positioned within the housing for establishing electrical communication between the equipment ports and a corresponding patch plugs. A flexible microstrip is also provided that, in a normal mode, provides a low return loss, low discontinuity flowpath between the equipment ports, while in a patched mode is flexibly urged away from an equipment port that is patched to the corresponding patch plug via the actuator such that the unpatched equipment port is terminated in its characteristic impedance.

10 Claims, 3 Drawing Sheets



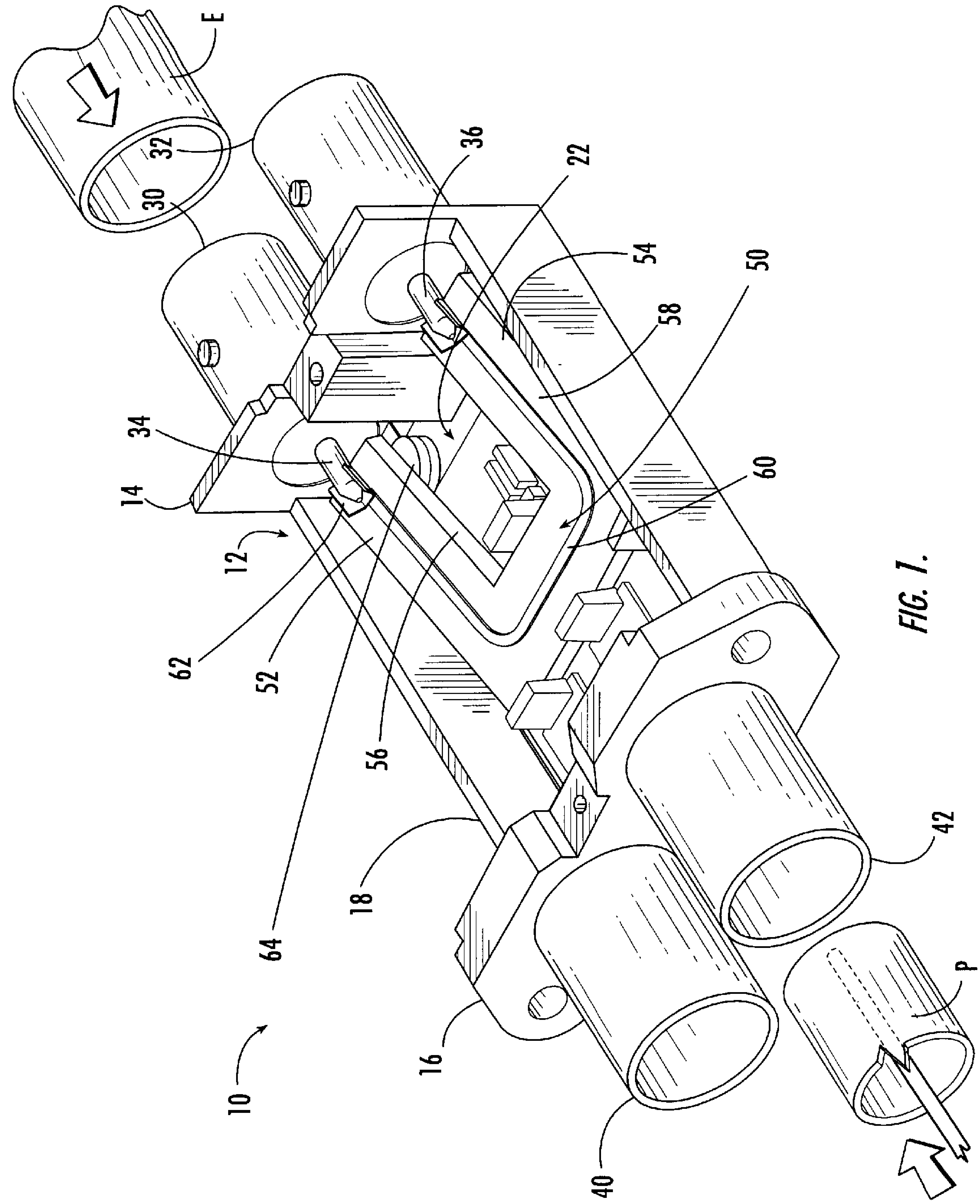


FIG. 1.

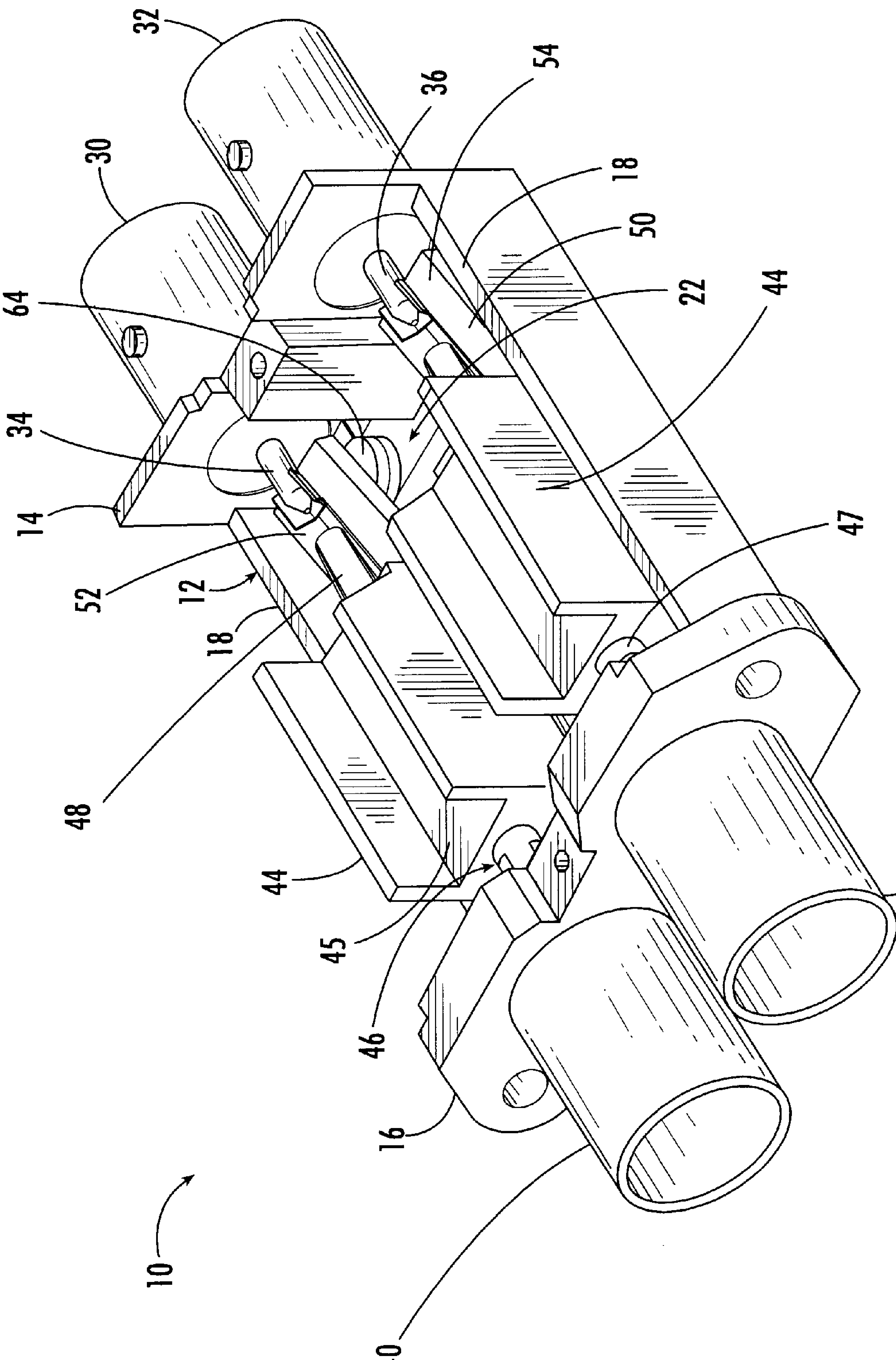


FIG. 2.

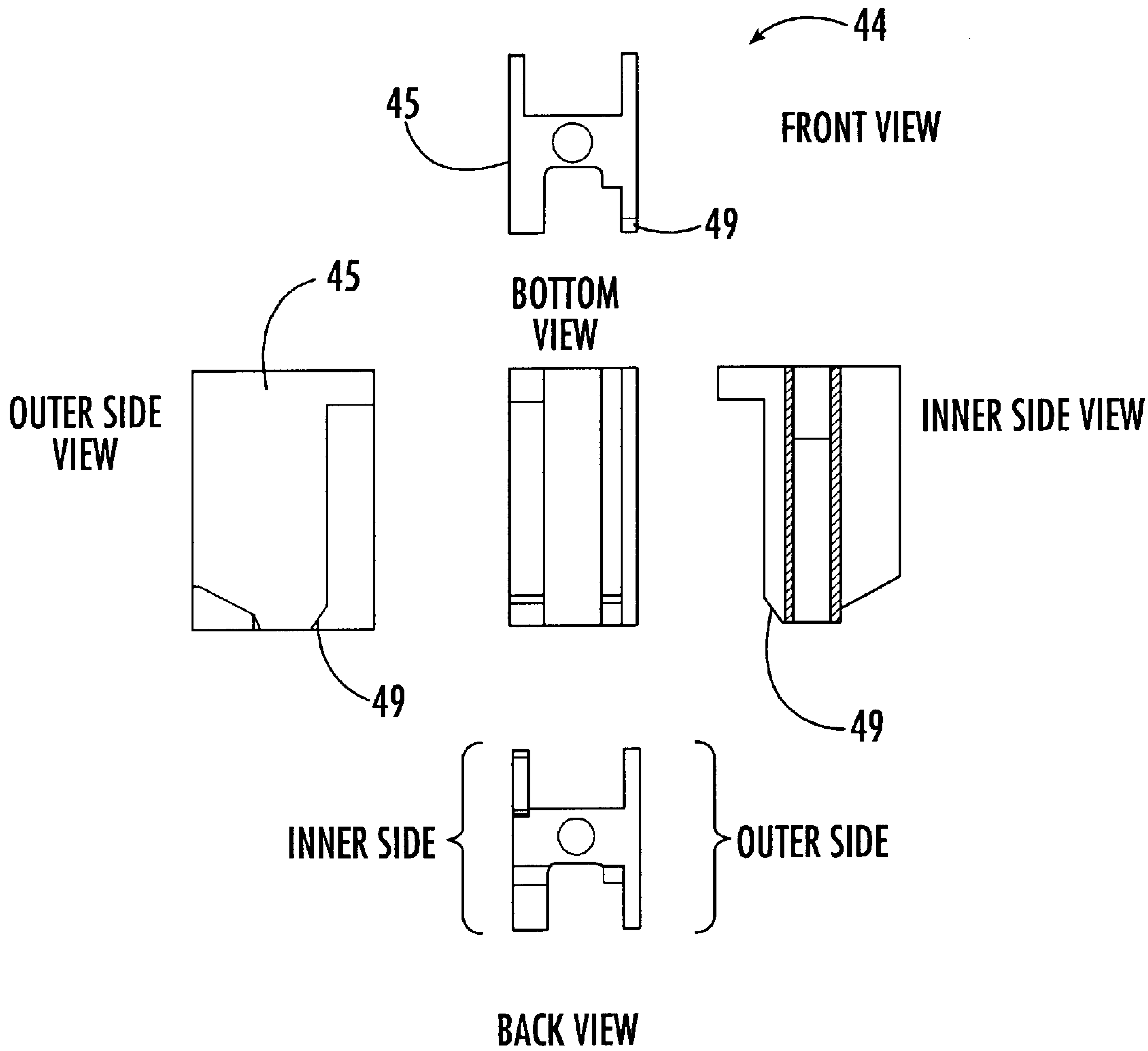

44
45
FRONT VIEW
49
45
BOTTOM VIEW
OUTER SIDE VIEW
INNER SIDE VIEW
49
49
INNER SIDE
OUTER SIDE
BACK VIEW

FIG. 4.

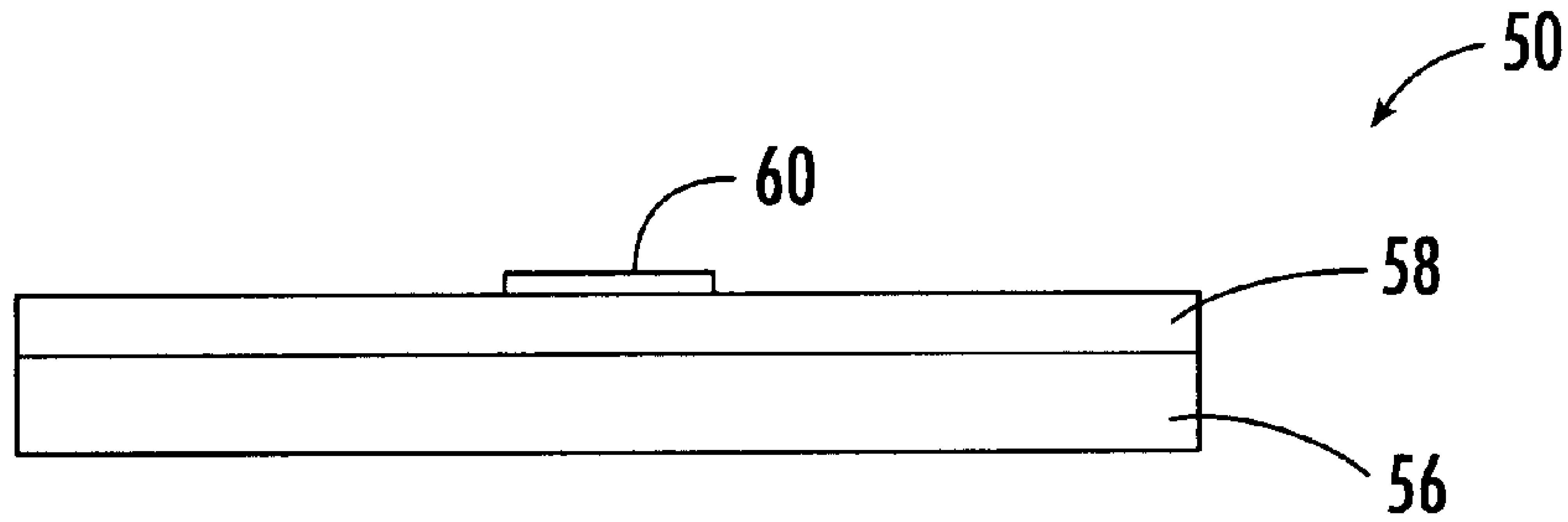

50
60
58
56

FIG. 3.

ELECTRICAL COUPLING AND SWITCHING DEVICE WITH FLEXIBLE MICROSTRIP

FIELD OF THE INVENTION

The present invention relates to electrical connectors, and more particularly to electrical coupling and switching devices for use in high frequency transmission rate applications.

BACKGROUND OF THE INVENTION

Electrical connectors and switching devices have been used for many years in various industries, such as the broadcast industry. The devices are used in electrical equipment systems to provide a transfer of electrical signal to different components of the particular system. The devices typically employ a mechanical-type action, such as a biasing action, in order to connect or disconnect various components of the system.

For example, a common type of connector and switching device or jack employs spring arms that are normally biased to provide electrical communication between two equipment plugs, such as standard BNC plugs, that are engaged in the device, typically on the same end of the device. The spring arms are individually moveable away from the normally biased position such that the equipment plugs can be terminated separately. In particular, a patch plug is often provided for urging a respective spring arm away from the normally biased position such that the patch plug is in electrical communication with one of the equipment plugs, while the remaining equipment plug is terminated through a resistor via the remaining spring arm.

Typically, these conventional jacks perform satisfactorily for standard television signals or for serial digital signals having a maximum bandwidth of about 750 megahertz. More specifically, the signal loss and discontinuity associated with these conventional jacks are not deleterious for most applications because most applications in the broadcast field for which they were designed do not require a high level of performance. However, with the advent of high definition television and other formats where the operating bandwidth is now beyond 2.4 gigahertz, conventional jacks do not provide effective signal carrying capacity as required for these applications. In particular, conventional jacks have excessive return losses at these high bandwidths. Thus, there is a need for an electrical switching jack that provides low discontinuity while minimizing return loss at bandwidths of about 1.5 GHz and higher. The jack, however, must be durable and capable of withstanding the repetitious cycling of the equipment and patch plugs.

SUMMARY OF THE INVENTION

These and other needs are provided by the present invention, which, in one embodiment, comprises an electrical coupling and switching device having a low-discontinuity, impedance-controlled electrical flowpath between two equipment plugs along a flexible microstrip. Advantageously, the flexible microstrip can be moved by insertion of a patch plug into the device in order to break the connection between the equipment plugs and establish electrical communication between the patch plug and the corresponding equipment plug.

In particular, the electrical coupling and switching device or jack in one embodiment comprises a housing defining first and second equipment ports, wherein each port includes a conductor pin. The conductor pins are adapted for connecting to the center conductor of a equipment plug, such as a coaxial or BNC plug, which is inserted into the respective equipment port. The housing further defines first and second patch ports for receiving first and second patch plugs, such as video-style plugs.

The jack also includes first and second insulative actuators positioned within the housing. Each actuator includes a conducting member that is positioned to be engaged by a patch plug when the patch plug is inserted into the respective patch port. The conducting member is also positioned such that as the patch plug is fully inserted into the respective patch port, the conducting member contacts the conductor pin of the respective equipment port so as to establish electrical communication or connection between the patch plug and the equipment port.

Advantageously, the flexible microstrip has first and second portions that, in a normal mode, are biased into contact with the conductor pins of the first and second equipment ports, respectively. In this regard, a connection is made between the first and second equipment ports when no patch plugs are inserted into the patch ports. More specifically, an impedance-controlled electrical flowpath is established along the flexible microstrip between the first and second equipment plugs in the normal mode, i.e., when no patch plugs are inserted into the patch ports.

When a patch plug, such as a video plug, is inserted into one of the patch ports, the patch plug engages the respective insulative actuator. As the patch plug engages the patch port, the actuator is urged toward the respective equipment port. This action causes the actuator to engage and urge the respective portion of the flexible microstrip away from and out of contact with the conductor pin on the respective equipment port, thus creating a patched circuit between the patch plug and the respective equipment port and an unpatched circuit to the remaining equipment port. Preferably, the actuator includes a ramped or angled surface for gradually engaging the respective portion of the flexible microstrip.

In one embodiment, the jack of the present invention also includes a resistive termination device, such as a resistor, that is positioned inside the housing so as to be contacted by the flexible microstrip when one of the insulative actuators urges the respective portion of the microstrip out of contact with the conductor pin of the respective equipment port. As the flexible microstrip contacts the termination device, the remaining unpatched equipment port is thereby terminated. In addition, the termination device preferably has the same impedance as the unpatched circuit, thereby substantially eliminating return loss. In order to facilitate contact between the termination device and the flexible microstrip, a conductive tab portion is attached to the flexible microstrip at each of its respective ends.

Thus, the jack of the present invention overcomes the problems mentioned above. In particular, the coaxial-to-flexible microstrip transition provides a more constant impedance in the normal mode than conventional jacks which employ spring arms to carry the signal between the equipment ports. In addition, the jack provides a low discontinuity flowpath between the equipment ports in the normal mode, which results in better signal integrity, particularly at bandwidths of 1.5 GHz and greater.

BRIEF DESCRIPTION OF THE DRAWINGS

While some of the objects and advantages of the present invention have been stated, others will appear as the description proceeds when taken in conjunction with the accompanying drawings, which are not necessarily drawn to scale, wherein:

FIG. **1** is a perspective view of a portion of an electrical coupling and switching device according to one embodiment of the present invention;

FIG. **2** is a perspective view of a portion of an electrical coupling and switching device according to the present invention showing a pair of insulative actuators;

FIG. **3** is a cross-sectional view of a flexible microstrip according to the present invention; and

FIG. **4** shows several views of an insulative actuator according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

Turning to FIGS. **1–4**, an electrical coupling and switching device or jack according to the present invention is generally designated by the numeral **10**. The jack **10** may be used in many different applications, but is particularly advantageous for use in high bandwidth applications, such as high definition television or other applications with bandwidths of 1.5 GHz or greater. In particular, the jack **10** comprises a housing **12** made from a die cast conductive material, such as nickel plated zinc, including a front wall **14**, a back wall **16**, and side walls **18**. The walls, **14**, **16**, **18** cooperate with a bottom wall **20** and a cover (not shown) to define a housing interior **22**. In one embodiment, the housing has a length of about 34 inches, a width of about 1.5–2.5 inches, and a thickness of about 0.5–1.0 inches.

The front wall **14** defines two equipment ports **30**, **32** to receive coaxial plugs, such as standard BNC-style plugs E (only one shown) having a center conductor surrounded by an outer sleeve. The equipment ports **30**, **32** include conductor pins **34**, **36**, respectively, that extend into the housing interior **22**. The conductor pins **34**, **36** are positioned such that the center conductors of respective coaxial equipment plugs E engage the conductors pins and establish electrical communication therewith. Although the conductor pins **34**, **36** are shown as having a generally circular cross section, the conductor pins can have other shapes and dimensions. The equipment ports **30**, **32** also engage the outer sleeves of the coaxial plugs in order to connect the outer sleeves to an electrical ground.

The jack **10** also includes a flexible microstrip **50** having first and second portions **52**, **54** that is positioned within the housing interior **22** proximate the front wall **14**. As shown in FIG. **3**, the flexible microstrip **50** comprises a ground element **56**, a dielectric layer **58**, and a conducting track **60** extending along an upper surface of the dielectric layer. Desired impedance of the microstrip **50** can be controlled by the thickness of the dielectric layer **58**, the dielectric constant of the dielectric layer, and the width of the conducting track **60**. More specifically, the microstrip **50** can be formed via flexible printed circuit board technology or by interposing a highly flexible, homogenous, isotropic polymeric sheet, such as polytetrafluoroethylene (PTFE), between two metal sheets, which can be formed from brass, copper, or other conductive metal. In one advantageous embodiment, the ground element **56** comprises a resiliently flexible conductive material, such as beryllium copper. The dielectric layer **58** is also highly flexible. As such, the microstrip **50** is resiliently flexible, and can withstand a minimum of 30,000 flexure cycles, as discussed more fully below.

In a normal mode, an electrical circuit is established from one equipment port to the other equipment port via the flexible microstrip. In particular, the electrical circuit, which in one embodiment has a characteristic impedance of 75 Ohms, is established by directing an electrical signal from one equipment plug, through the respective equipment port **30** and conductor pin **34** to the flexible microstrip **50**. The signal is further directed along the conducting track **60** of the microstrip to the conductor pin **36** of the other equipment port **32**, which is in electrical communication with the other equipment plug. In order to maintain a continuous ground plane, the microstrip **50** should make sufficient contact with the equipment ports **30**, **32**. To facilitate this contact, a grounding device (not shown) is provided between the ground element of the microstrip and the housing **12** proximate the wall **14**.

A conductive tab portion **62** is secured to each end of the microstrip **50** for facilitating positive contact between the microstrip and the conductor pins **34**, **36**. In addition, each conductive tab portion **62** is wrapped around the respective end of the microstrip **50** so that the signal along the conducting track **60** is carried to the opposite surface of the microstrip for engagement with a resistive termination device **64**, as discussed more fully below. Advantageously, the conductive tab portion **62** in conjunction with the flexible microstrip **50** substantially eliminates discontinuity between the equipment ports **30**, **32**.

The back wall **16** defines two patch ports **40**, **42** adapted to receive patch plugs P (only one shown). In one embodiment, the patch ports **40**, **42** are adapted to receive coaxial video-style patch plugs, although other types of patch plugs may also be used. The patch ports **40**, **42** are formed in a conventional manner for releasably securing the patch plugs to the jack **10**, and define openings so that the patch plugs can extend therethrough into the housing interior **22**.

As shown in FIGS. **2** and **4**, the jack **10** also includes a pair of insulative actuators or shuttles **44** that are movably disposed in the housing interior **22**. In particular, the shuttles **44** have a body portion **45** formed of a lubricious, insulative material, such as acetal resin. Suitable acetal resins are available from DuPont under the Delrin® trademark. Other materials may also be used, such as PTFE. In addition, the shuttles **44** include a conducting portion or member **46** extending therethrough. In should be noted, however, that the conducting member **46** does not have to extend through the body portion **45**, but instead could extend around the body portion in the shape of a full or partial band without parting from the spirit and scope of the present invention. The conducting member **46** includes a patch plug contact **47** for engaging the respective patch plug and a socket **48** or the like for engaging the conducting pins **34**, **36** of the respective equipment ports. In one embodiment, the shuttles **44** may include a bias member (not shown), such as a spring, in order to hold the shuttles in a position proximate the back wall **16** unless acted upon by a sufficient external force. The bias member should also be capable of returning the shuttle to a fully disengaged position proximate the back wall. The body portion **45** of the shuttle **44** generally has an "H" shape that facilitates movement along the housing interior **22**, although other shapes may also be used. More specifically, the shape of the shuttle **44** allows suitable cooperation with the bottom wall **20** and the cover of the housing to form a "track and rail" system along the housing interior **22** of the jack **10**. This design ensures minimal wear on the jack components and maintains proper alignment between the shuttles **44** and the equipment ports **30**, **32**.

In a patched mode, a video-style patch plug P is inserted into a particular patch port, such as the patch port designated by the numeral **40**. This may be desirable if there is a need to patch around a particular piece of equipment connected to the jack **10** at one of the equipment ports, such as the equipment port designated by the numeral **32**. As the patch plug is fully seated into the patch port **40**, the patch plug urges or pushes the shuttle **44** towards the respective equipment port **30**, which preferably is located across the interior portion **22** of the housing **12** along a common longitudinal axis with the patch port **40**. As the shuttle **44** is urged toward the equipment port **30**, the shuttle **44** engages the flexible microstrip **50**. In one embodiment, the body portion **45** of the shuttle **44** includes an angled or ramped bottom surface **49** substantially corresponding to the angle of the flexible microstrip **50** when the microstrip is in the normal mode in order to facilitate gradual engagement therebetween. As such, as the shuttle **44** moves towards the respective equipment port **30**, the shuttle progressively engages the first portion **52** of the flexible microstrip **50** and urges the first portion of the microstrip away from the respective conductor pin **34**. When the patch plug is fully seated in the patch port **40**, the socket **48** extending from the shuttle **44** engages and mates with the conductor pin **34** extending from the corresponding equipment port **30**. As a result, an electrical patch circuit is established between the patch plug and the equipment port **30** via the shuttle **44**, cover, and conductor pin **34**. Advantageously, the patch circuit provides a constant impedance for the patched signal.

According to one embodiment of the present invention, the unpatched equipment port **32** is terminated in its characteristic impedance while the shuttle **44** moves toward the corresponding equipment port **30** and urges the first portion **52** of the flexible microstrip **50** away from the conductor pin **34**. More specifically, as the patch plug is fully seated in the patch port **40** and the socket **48** has engaged the conductor pin **34**, the tab portion **62** connected to the flexible microstrip **50** proximate the first portion **52** thereof is urged away from the conductor pin **34** and contacts the resistive termination device **64**.

As shown in FIGS. **1** and **2**, the resistive termination device **64** comprises a resistor of the same value as the characteristic impedance of the system, such as 75 Ohms. There is a contact for the termination device **64** beneath each portion **52** and **54** of the microstrip. Preferably, a high frequency or microwave resistor is used and the contacts are nickel-passivated or otherwise treated to ensure reliable contact. To minimize return loss, the circuit on the flexible microstrip **50** should make suitable contact with the resistor, which in turn makes contact with the ground. Preferably, the grounding should occur in close proximity to the resistor. In this regard, the conductive tab portion **62** extends around the end of the flexible microstrip **50** such that in the patched mode the tab portion contacts the resistor and thus terminates the unpatched equipment port, which in the present example is the port **32**. In addition, the ground element **56** of the microstrip **50** comprises a resilient material, which is capable of returning the flexible microstrip **50** back into contact with the conductor pin **34** when the shuttle **44** is moved away from the microstrip, thereby transferring from the patched mode to the normal mode.

Although the foregoing only describes a patch mode using a single patch plug in conjunction with one of the equipment ports, it is also within the scope of the present invention to patch both equipment ports **30**, **32** to corresponding patch plugs that are inserted into the patch ports **40**, **42** of the jack. When both equipment ports **30**, **32** are in the patched mode, both shuttles **44** are fully engaged so that the flexible microstrip **50** has moved away from both conductor pins **34**, **36** of the equipment ports **30**, **32**, respectively. To return one of the equipment ports to the normal mode, for example the equipment port designated by numeral **30**, the patch plug is removed from the corresponding patch port **40**, which causes the corresponding shuttle **44** to move away from the equipment port and return to its retracted position proximate the back wall **16**. As the shuttle **44** moves away from the equipment port **30**, the first portion **52** of the flexible microstrip **50** moves away from the termination device **64** and contacts the equipment port. Because the second portion **54** of the microstrip is still in contact with the termination device **64**, the equipment port **30** is terminated as described above while the other equipment port **32** remains in the patched mode. To return to the normal mode for both equipment ports **30**, **32**, both patch plugs must be removed from the respective patch ports **40**, **42** so that both portions **52**, **54** of the flexible microstrip **50** return to the normal position, as described above. Advantageously, the patch circuits can be repetitively opened and closed while maintaining the impedance of the circuit between the equipment ports **30**, **32**.

Thus, the present invention provides an electrical coupling and switching device or jack **10** for coaxial applications having a low-loss, low-discontinuity, constant-impedance electrical flowpath for coaxial signals and, when in the patched mode, terminating the unpatched equipment port in a low return loss impedance that is substantially equivalent to the system impedance while the patched equipment port maintains a low-loss and low-discontinuity patched signal. Advantageously, the jack of the present invention has minimal return loss and discontinuity at bandwidths of 1.5 GHz and higher, yet is durable enough to withstand repetitious cycling of the flexible microstrip **50** and associated components from the normal mode to the patch mode and vice versa. As such, the present invention provides a jack and a method of patching a circuit that overcomes the problems mentioned above.

Many modifications and other embodiments of the invention will come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. For example, the jack **10** may be designed such that the equipment parts **30**, **32** are positioned at an angle, such as 90° or other angle, relative to the patch ports **40**, **42**, instead of each equipment port having a common longitudinal axis with the respective patch port as illustrated in the drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

That which is claimed:

1. An electrical coupling and switching device, comprising:

a housing defining first and second equipment ports each having a conductor pin for connection with a center conductor of a respective equipment plug inserted into the equipment port the housing further defining first and second patch ports for receiving first and second patch plugs;

first and second insulative actuators each having a conducting portion and positioned to be engaged by the respective patch plug inserted into the respective patch port and to be urged by the patch plug toward the opposite equipment plug such that a conductor of the patch plug contacts the conducting member of the actuator which in turn contacts the conductor pin of the equipment port so as to establish connection between the patch plug and the equipment port; and

a flexible microstrip comprising a conducting track proximate a dielectric layer, the flexible microstrip having first and second portions biased into contact with the conductor pins of the first and second equipment ports, respectively, so as to establish a connection therebetween when no patch plugs are inserted into the patch ports, the insulative actuators and microstrip being structured and arranged such that each actuator urges the respective portion of the microstrip out of contact with the conductor pin on the respective equipment port when the patch plug is inserted into the respective patch port.

2. An electrical coupling and switching device according to claim **1**, wherein the microstrip has a substantially constant impedance.

3. An electrical coupling and switching device according to claim **1**, wherein the first patch port is positioned opposite the first equipment port, and the second patch port is positioned opposite the second equipment port.

4. An electrical coupling and switching device according to claim **1**, wherein the first and second insulative actuators include a ramped surface for gradually engaging the flexible microstrip.

5. An electrical coupling and switching device according to claim **1**, wherein the flexible microstrip includes a resiliently flexible material.

6. An electrical coupling and switching device according to claim **1**, further comprising a resistive termination device being positioned to be contacted by the microstrip when one of the insulative actuators urges the respective portion of the microstrip out of contact with the conductor pin of the respective equipment port so as to establish electrical contact between the portion of the microstrip and the contact and thereby terminate the other equipment port in the termination device.

7. An electrical coupling and switching device according to claim **6**, wherein the resistive termination device is a 75 Ohm resistor.

8. An electrical coupling and switching device according to claim **6**, further comprising a conductive tab portion attached to the flexible microstrip for facilitating contact between the microstrip and the resistive termination device.

9. An electrical coupling and switching device according to claim **1**, further comprising a resiliently flexible ground element, the dielectric layer being adjacent the conducting track and the ground element being adjacent the dielectric layer, wherein the ground element is capable of returning the microstrip to a first position from a biased second position.

10. An electrical coupling and switching device according to claim **9**, wherein the ground element comprises beryllium copper.

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